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1 author:

Peter De Maeyer
Sophia University

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Applying the peak-end rule to reference prices

Peter De Maeyer Hooman Estelami

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Peter De Maeyer
Marketing, Singapore Management University, Singapore, and

Hooman Estelami
Graduate School of Business, Fordham University, New York, New York, USA

Abstract

Purpose – The objective of this paper is to propose and empirically test a potential mechanism for how consumers form reference prices. The proposed peak-end rule of reference price formation says that reference prices are formed as a weighted average of the highest observed price and the most recent price.

Design/methodology/approach – The authors argue why the peak-end rule observed in satisfaction contexts may also apply to the process by which consumers form reference prices. They then test the proposed peak-end rule using IRI scanner panel data for decaffeinated coffee.

Findings – Fit and predictive validity of a choice model improves when a reference price term based on the peak-end rule is added. While the most recent price has a greater impact on reference price, the effect of the highest observed peak price is also significant, managerially and statistically.

Research limitations/implications – The study provides evidence for a novel and behaviorally plausible reference price formation process.

Practical implications – Temporarily charging a high price has a longer-lasting effect on reference price than would be suggested by other reference price models, which typically involve a quickly decaying lag effect. Temporarily charging a very high price to restore the reference price may therefore be a useful pricing tactic.

Originality/value – While the peak-end rule is amply supported as a mechanism by which consumers form global satisfaction judgements, its application to reference price formation is novel, and has some potentially useful implications.

Keywords Pricing, Reference prices, Satisfaction, Peak-end rule, Choice models, Customer satisfaction

Paper type Research paper

1. Introduction

A reference price is a psychological benchmark against which consumers evaluate offered prices (Mazumdar *et al.*, 2005; Erdem *et al.*, 2010). The existence of such a benchmark is widely accepted in marketing and has the status of an empirical generalization (Kalyanaram and Winer, 1995). The underlying premise is that consumers do not respond merely to absolute price levels, but also to the gap against one or more reference prices. Various internal price benchmarks may be used by consumers towards this end (Monroe, 1973; Mazumdar *et al.*, 2005): the reservation price (the highest price one is willing to pay), the lower bound on price (if price is used as a quality cue), the target price, the fair price, the most recently observed price, and so on. Consistent with current practice in the empirical literature, we will conceptualize the reference price as the price the consumer considers the current price of the product, and which can therefore be viewed as the anticipated price (Winer, 1986; Chandrashekaran, 2011). In this conceptualization, the gap between observed price and reference price is referred to as "sticker shock". In a landmark study, Winer (1986) showed a brand choice model incorporating sticker shock to have better empirical fit compared to a pure demand model using price only. This shows that sticker shock acts as an independent construct from price, in that it has an impact on brand choice beyond that of price alone. Numerous other studies have shown reference prices to be an important construct in understanding consumers' price evaluations and subsequent purchase decisions (for a recent review, see Mazumdar *et al.*, 2005).

Considering the importance of the reference price construct in the marketing literature, relatively little empirical research has explored the process by which reference prices are formed in consumers' minds (Briesch *et al.*, 1997). Increasing our understanding of this would be of interest to both academicians and data analysts in industry. Most models of reference price formation used to date have been adopted from the economics literature: extrapolative expectations (Ferber, 1953; Drechsler and Natter, 2011), rational expectations (Muth, 1961; Sun, 2005; Erdem *et al.*, 2010), and adaptive expectations (Nerlove, 1958; Zhang *et al.* 2011). These economic models of reference price formation perform

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reasonably well empirically, but have been criticized for not offering a plausible representation of consumers' cognitive processes, as we will discuss below.

Unrelated psychology research, however, suggests a potential mechanism by which consumers might form reference prices. Original research in the area of satisfaction has shown that consumers often use simplifying heuristics to form integrative satisfaction judgements on the basis of individual satisfaction episodes over time (Kahneman *et al.* 2003). Specifically, overall satisfaction with an extended experience will be mostly determined by the satisfaction peaks (high or low) felt with individual episodes, and satisfaction felt with the final episode in the experience. This heuristic is called the peak-end rule, and it has been shown to operate in a variety of satisfaction-related settings. While primarily a heuristic used in satisfaction contexts, we will argue why it might also apply in the context of reference price formation, and test it empirically against benchmark models.

2. Models of reference price formation

Differing formulations of reference price formation have been used in the literature (Winer, 1986; Nasiry and Popescu, 2011). This section will briefly outline commonly used models of reference price formation.

2.1 Extrapolative expectations model

The extrapolative expectations model (Ferber, 1953; Drechsler and Natter, 2011) assumes that consumers' expectations of price are extrapolations of recent experiences. The model hypothesizes that price expectations are based on previous prices, with higher weight given to more recent ones. This can be represented as an exponentially smoothed average of the previous two periods' prices:

$$P^r_{ijt} = \lambda P_{ijt-1} + (1-\lambda)P_{ijt-2}$$

In this, P_{ijt} represents the actual price observed by consumer i for brand j at time P^r_{ijt} represents the reference price of consumer i for brand j at time t; and λ determines the relative weighting of the two periods. Examples of authors utilizing variants of this formulation are Winer (1986), Greenleaf (1995) and Erdem *et al.* (2001). This formulation has the advantage of economy, but the implicit assumption that people gradually forget previously observed prices may be problematic in the context of frequently purchased consumer goods, for which price knowledge is likely to be better (Estelami and De Maeyer, 2004).

2.2 Adaptive expectations model

The adaptive expectations model, originally proposed by Nerlove (1958) holds that consumers adjust their reference price over time at the hand of new price information. Under this model, reference prices are formed as a weighted average of the previous period's reference price and actual price.

$$P^r_{ijt} = \lambda P_{ijt-1} + (1-\lambda)P^r_{ijt-1}$$

This model assumes that reference prices are retrieved, updated, and then stored again in long-term memory. This is mathematically convenient and yields acceptable empirical results (Johnson *et al.* 1995), but seems a poor representation of the underlying cognitive process. Another critique of the adaptive expectations model is that it ignores many other factors that might be expected to influence a consumer's reference price. For instance, word-of-mouth (Mazumdar *et al.* 2005), price-quality inferences (Ding *et al.* 2010), competitor prices (Kumar *et al.* 1998), retailer actions (Biswas and Blair, 1991), promotional tactics (DelVecchio *et al.* 2007; DelVecchio and Craig, 2008), firm type (Lowe and Alpert, 2010), level of involvement (Chandrashekaran, 2012), and product category (Bridges *et al.* 1995) have been shown to influence reference price. The failure of the extrapolative and adaptive expectations models to account for such external factors led Muth (1961) to propose the rational expectations model.

2.3 Rational expectations model

The rational expectations model assumes that consumers' expectations of price are not systematically biased. In other words, consumers' price expectations are equal to actual prices plus a random error term with expected value equal to zero:

$$P^r_{ijt} = P_{ijt-1} + \in_{ijt}$$

As before, the subscripts i, j, and t indicate the consumer, brand and time period. In this model, consumers may be individually wrong, but their predictions will be correct on average. They are assumed to understand or intuit the economic theory principles sellers use to make pricing decisions. While the rational expectations model yields reasonable empirical fit in aggregate prediction models, several studies show the adaptive expectations assumption to show superior fit (Johnson *et al.* 1995; Chow, 1989). An additional critique against rational expectations is that it is unrealistic at the individual level (Bray and Kreps, 1981; Lovell, 1986; Van Raaij, 1989). The face validity of the rational expectations assumption is hampered by unrealistic assumptions about consumers' capacity and motivation to do so (Mehta *et al.* 2004; Zhang *et al.* 2011). Given that even professional economists have a poor record of forecasting prices (e.g. Frydman and Phelps, 1986), it is not credible to assume that consumers will succeed at this task.

2.4 The peak-end model

The peak-end model we are about to propose is inspired by a similar one in satisfaction research. Most experiences in life do not occur in a singular moment, but take place over a period of time. Specific incidents taking place during an extended experience are likely to trigger satisfaction responses. This raises the question about what is the best model to combine these individual evaluations of incidents into an overall evaluation of the entire experience. In a rational framework, it would be reasonable to posit that the overall utility of an experience is the sum of the individual component utilities experienced at different times. In such a model, adding new, positively evaluated incidents to an experience would increase its global evaluation. Likewise, adding negative experiences would lower it. There would be no interaction among component utilities, and all component utilities would have equal weight.

Varey and Kahneman (1992) and Fredrickson and Kahneman (1993) conducted a series of experiments to explore utility integration rules and concluded that the rational framework is a poor representation of how people form and remember an overall evaluation of an experience.

Instead, they found ample support for the so-called peak-end rule, which says that "remembered utility" is based almost entirely on the most salient moments of an extended experience, with the most salient moments occurring with the utility peak(s) of the experience and the ending. Other components of the experience may be remembered, but have little impact on remembered utility. In the words of Kahneman *et al.* (2003):

> We judge our past experiences almost entirely on how they were at their peak (pleasant or unpleasant) and how they ended. Virtually all other information appears to be discarded, including net pleasantness or unpleasantness and how long the experience lasted.

In the first of these studies (Varey and Kahneman, 1992), subjects were given descriptions of momentary utility ratings during successive intervals of a hypothetical scenario, and then asked to provide an overall utility. The researchers found that that the peak-end model fit the data much better than the rational model of additive utility described earlier. They found that subjects place disproportionate weight on the most aversive outcome and the final outcome. Together, utility with the peak and the end of the experience accounted for 94 percent of the variance in overall utility. Countless replication studies support the peak-end rule, both for positive and negative experiences, for instance, for perceptions of pain (Ariely, 1998; Redelmeier and Kahneman, 1996), advertisements (Baumgartner *et al.* 1997), life satisfaction (Schkade and Kahneman, 1998), and sounds (Schreiber and Kahneman, 2000).

Building on the preceding discussion, it would not be unreasonable to assume that reference prices are also subject to the peak-end phenomenon. The significance of the peaks in the peak-end rule is that they are highly salient. Similarly, extreme prices are likely to be salient to the consumer. Prospect theory (Kahneman and Tversky, 1979) predicts that high prices are particularly salient, since consumers are more sensitive to losses (unexpectedly high prices) than gains (unexpectedly low prices). Furthermore, the phenomenon of sticker shock is related to the concept of satisfaction. Indeed, sticker shock is essentially a (dis)satisfaction response to an unexpectedly high observed price level. Based on the above, we hypothesize a peak-end model of reference price that says that reference prices are based on the highest past price and the last observed actual price.

Mathematically, we state the peak-end model of reference price as follows:

$$P^{r}_{ijt} = \lambda P_{ijt-1} + (1-\lambda) P^{high}_{ijt-1}$$

In this, the "high" superscript refers to the highest price observed in the time series.

Based on the above discussion, we wish to test the following hypotheses:

H1. The peak-end model is a valid formulation of reference price. Its inclusion in a choice model results in improvements in model fit versus a model using price and non-price covariates only.

An alternative way of looking at the first hypothesis is as follows:

H2. In a brand-choice model incorporating the proposed peak-end formulation of reference price, the peak price carries a non-zero weight.

3. Data and analytical approach

As other authors have noted (e.g. Winer, 1986), reference price is an unobservable construct, hence we are unable to measure it directly. We can infer it empirically on the basis of its impact on other marketing variables, however. We obtained IRI scanner panel data in order to calibrate a choice model and to allow us to test the peak-end model empirically against two baseline models. The dataset contains decaffeinated ground coffee purchases for a period of 276 household over a period of 84 weeks, for a total of 3,265 purchases. Decaffeinated coffee was chosen as a product category because consumers tend to be brand loyal and no close substitute categories are available to offer consumers dissonance-free alternatives in case of sticker shock. An unexpectedly high price is therefore likely to be salient since a difficult decision needs to be made whether to accept it or go without the desired product. Another advantage of decaffeinated coffee is that the number of brands is limited, and hence a sufficient number of observations per brand are available. The dataset keeps track of purchase quantity, regular and promoted price, and other promotional variables. The data were split in a calibration sample (176 households and 2,032 purchase incidents) and a holdout sample (100 households and 1,233 purchases incidents) to enable us to assess predictive validity. To ensure a sufficient number of purchase incidents, only the top four brands were included in the study. Together they account for more than 80 percent of purchases. The baseline brand choice model was formulated using the common multinomial logit function:

$$\Pr ob^{baseline}_{ijt} = \exp\left(\sum_{k=0}^{4} \beta_i X_{kijt}\right) \Big/ \sum_{m=1}^{4} \exp\left(\sum_{k=0}^{4} \beta_i X_{kimt}\right)$$

In this, the variables are defined as follows:

X_{0j} = Brand constant.
X_{1ij} = Brand loyalty of household i to brand j. These variables are calibrated on the first 32 weeks of purchase history, and measured by the brand's share of purchases by the household. We include this variable as a measure of heterogeneity among households.
X_{2ijt} = Brand purchase dummy, indicating whether household i bought brand j in period t.
X_{3ijt} = Price paid by household i for brand j in period t.
X_{4ijt} = Promotional dummy, indicating whether household i bought brand j in period t on promotion.

The peak-end model is operationalized by adding a fifth variable to the baseline brand choice model, namely sticker shock: $X_{5ijt} = X_{3ijt} - P^{r}_{ijt}$ with P^{r}_{ijt} the peak-end formulation of reference price proposed earlier. Relative improvement in fit between the models will then allow us to assess the merits of the peak-end model of reference price.

4. Empirical results

The model coefficients were estimated in SAS using the maximum likelihood procedure. The estimation results can be found in Table I. The null model, included to provide a baseline maximum likelihood level, refers to a model of brand choice containing only brand intercepts. In this model, choice probability of each consumer is equal to market share. The

Table I Multinomial logit results

Parameter	Null model		Base model		Peak-end model	
Brand intercept 1	− 0.699	(− 9.97)	− 0.359	(− 2.85)	− 0.482	(− 3.71)
Brand intercept 1	0.104	(1.86)	0.464	(4.50)	0.313	(2.92)
Brand intercept 1	0.154	(2.80)	0.599	(5.32)	0.323	(2.58)
Loyalty	N/A		2.710	(20.65)	2.656	(20.12)
Last purchase dummy	N/A		1.203	(13.81)	1.401	(14.49)
Promotion dummy	N/A		2.963	(26.68)	3.000	(26.56)
Price	N/A		− 3.062	(− 14.83)	− 1.821	(− 5.69)
Sticker shock	N/A		N/A		1.432	(4.97)
Log-likelihood	− 3,098.00		− 1,065.75		− 1,053.11	

base model adds a set of non-reference price covariates to the null model: brand loyalty, last purchase dummy, last price paid and promotion dummy. The final model adds reference price based on the peak-end model as an independent variable.

As can be seen from Table I, and consistent with the extant literature, the base model is a very significant improvement over the null model. The relative magnitude of the model coefficients' *t*-values are also consistent with prior research results. Price and promotional coefficients are high, reflecting the known high price elasticity for consumer goods (Farley *et al.* 1995). The addition of reference price leads to a smaller but still significant improvement in model fit. As might be expected, the coefficient of price drops significantly after adding the sticker shock variable, but remains highly statistically significant. This is evidence that price and reference price (sticker shock) are independent constructs. If sticker shock represented merely an alternative way of formulating the impact of price, then multicollinearity would be the case, meaning that the coefficients of price and sticker shock cannot be independently estimated, resulting in high variances. The *t*-values of both variables have high absolute values (5.69 and 4.97), however, so we may rule out the possibility that these variables represent separate measurements of the same construct.

Further analyzing the results in Table I, the peak-end reference price addition to the base model improves the U-squared statistic by .62 percent. This is a small but worthwhile improvement, and is statistically significant (Chi-squared value of 25.03; $p < 0.01$). It is therefore worthwhile to introduce a peak-end reference price formulation to brand choice models, and we conclude that *H1* is supported.

Note that our reference price model contains an unknown carryover constant λ. The value of λ was estimated by varying its value between 0 and 1, and finding the value that maximizes the log-likelihood of the brand choice model. This lead to the estimate $\lambda \approx 0.7$, indicating a higher relative weight for the final price in reference price formation. However, the peak price retains a significant weight with a value of $(1 - \lambda) = 0.3$. The second hypothesis that the peak price has a non-zero weight follows directly from the first. Indeed, assuming a zero weight for the peak price implies $\lambda = 1$, which is the baseline model, which we have shown to be inferior to the peak-end model based on $\lambda = 0.7$. We conclude that the peak price has a statistically significant effect on consumers' reference price, and that for the tested dataset, its impact on the reference price is just short of half the impact of the final price (0.3 versus 0.7).

In order to further validate the model results, the estimates from the calibration group were used to form predictions of brand choice for the holdout sample. The null model performs poorly, with only 28.8 percent of brand choice predictions correctly classified. For the base model, this improves to 84.0 percent correct classifications. Incorporating the peak-end formulation yields 85.2 percent correct classifications of brand choice. This is a small but meaningful improvement in predictive validity, and we therefore conclude that it is worthwhile to include a peak-end formulation of reference price in choice models.

5. Discussion

The above analysis shows the peak-end model of reference price to be a valid conceptualization of the construct. Our empirical analysis of ground decaffeinated coffee data shows the peak-end model to deliver statistically significant improvements over a base model not containing reference price. Compared to previous models of reference price formation, the peak-end formulation has arguably a stronger behavioral rationale, in that it builds on a large body of empirical work supporting the peak-end rule in a variety of contexts (Kahneman *et al.* 2003). Even though most of this work is in the satisfaction domain, the concept of reference price is closely linked to satisfaction via the concept of sticker shock, which is essentially a satisfaction response to an observed price level.

If one accepts the notion that the peak-end formulation constitutes a behaviorally more plausible process of reference price formation, one can derive some implications for managers who need to make price and promotions decisions. First, our results show that the peak price has a nonzero weight in the reference price. This means that it may be to the benefit of the firm to occasionally raise the price of the brand above a level that might normally be considered desirable, as a tactic to restore the reference price. Such a tactic of intentional sticker shock carries obvious risks and should be carefully considered against potential downsides. Moreover, this tactic seems best suited to frequently purchased product contexts, where the frequency of sales minimizes the impact of a lost sale during the peak-price period. Based on the structure of the peak-end rule, this tactic needs to be used only sparingly and for a short time period to be effective.

6. Study limitations and future research

Our results were obtained from the analysis of scanner panel data for one product category only. Future studies should replicate these findings in other product contexts. While we expect the peak-end rule to be valid for other product categories than the one tested, the relative weights of final to peak price may be quite different. These results should be tested not only for frequently purchased products, but also for infrequently purchased and/or high-involvement products.

One of the reasons we chose decaffeinated coffee as a category was that brand and category loyalty is quite strong, making consumers more likely to accept or at least contemplate a high price. Categories where this might also be the case are essential goods and services like gasoline, electricity, medical services, basic food staples, repairs and maintenance products. Future research could study category effects depending on the substitutability of the product category. We expect the impact of the peak price to be reduced when readily substitutes are available.

Although prospect theory predicts a stronger peak-price effect for high prices (because they represent a loss rather than a gain), it would be of interest to extend the study to include low peak prices. There is a substantial literature in marketing showing that frequent promotional discounts erodes consumers' reference price (Greenleaf, 1995; Krishna *et al.*, 1991). If the finding holds that the low peak price has a significant effect on reference price, the managerial implication would be to avoid deep discounts in particular, as their impact would be particularly deleterious. This is because the peak-end rule suggests the magnitude of discounts to be especially important, even if such large discounts are only rarely available. Another implication is that it does not matter if the discount is offered only rarely.

Other future research could investigate how long-lasting the effect of peak price is. The peak-end rule suggests that the effect is quite durable, but it would be worthwhile investigating where the limit lies, and what contextual factors are important. In many product contexts, prices change over time and consumers are aware that historical prices are not always realistically available anymore. This suggests that further refinements could be made to reference price models in the pursuit of improved predictive ability of choice models.

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About the authors

Peter De Maeyer is an Assistant Professor of Marketing at Singapore Management University. Prior to this appointment, he was an Assistant Professor of Marketing at Georgetown University. He has an MSc in Electrical Engineering from the University of Ghent (Belgium), an MBA from Helsinki School of Economics (Finland), and a PhD in Marketing from Columbia University. His work experience includes two years in internal consulting for Neste Oy, a Finnish oil and chemicals group, and three and a half years as a management consultant with the Monitor Group. His research has appeared in journals such as the *Journal of Retailing*, *Journal of Business Research*, *Journal of Product & Brand Management*, and *Journal of Financial Services Marketing*. Peter De Maeyer is the corresponding author and can be contacted at: peter@smu.edu.sg

Hooman Estelami is Professor of Marketing at the Graduate School of Business, Fordham University. He received his PhD in marketing from Columbia University and his MBA from McGill University. His areas of research specialization are financial services marketing, customer service management, and pricing. His research has appeared in journals such as the *Journal of Retailing*, *Journal of the Academy of Marketing Science*, *International Journal of Research in Marketing*, *Journal of Business Research*, *International Journal of Bank Marketing*, *Journal of Product & Brand Management*, *Journal of Services Marketing*, *Journal of Service Research*, *Journal of Financial Services Marketing*, *Marketing Education Review*, and elsewhere. He is the Editor of the *International Journal of Bank Marketing* and the author of three books and he has received multiple awards for his teaching and research.